

CAPACITOR BASED FORCE SENSOR

FIELD OF THE INVENTION

[0001] The present invention relates to force-based touch sensors, and more particularly relates to controlling spacing between electrodes of a force-based touch sensor.

BACKGROUND

[0002] The ability to sense and measure the force and/or location of a touch applied to a surface is useful in a variety of contexts. As a result, various systems have been developed in which force sensors are used to measure properties of a force (referred to herein as a "touch force" or an "applied force") applied to a surface (referred to herein as a "touch surface"). Force sensors typically generate signals in response to the applied force that may be used, for example, to locate the position of an applied force on the touch surface.

[0003] Determining the location of an applied force to a touch surface is of particular interest when the touch surface is that of a computer display or a transparent overlay in front of a computer display. Furthermore, the need for small, lightweight, and inexpensive devices that are capable of determining touch location is increasing due to the proliferation of mobile and hand-held devices, such as personal digital assistants (PDAs). The touch screens that perform this function may be built with a number of possible technologies. In addition to the force principal just mentioned, capacitive, resistance, acoustic, and infrared techniques are among those that have been used.

[0004] The force principal has some potential advantages over competing technologies. Since force techniques may be applied to any overlay material, or indeed to the entire display itself, there is no need to interpose materials or coatings with low durability or poor optical properties. Also, since touch force is the basis for perceiving the touch input, the sensitivity of a force-based device is predictable to the user. With capacitive measurement, for example, touch threshold varies with condition of the user's skin, and with interposing materials, such as a glove. Stylus contact typically gives no response. With resistive measurement, threshold force depends on the size of the contact area, and so is very different between stylus and finger. Acoustic measurement depends on the absorptive characteristics of the touching material; and with infrared, a touch may register when there has been no contact.

[0005] In spite of the advantages of force-based technologies, resistive and capacitive technologies have dominated in the touch screen market. This reflects residual difficulties with known force techniques, which must be overcome to realize the potential of force technology.

[0006] Among these difficulties are excessive force sensor size, especially the width and thickness of the sensor. Making a force sensor that has a size practical for use in very thin or very small devices has proven to be very difficult. Excessive sensitivity to transverse forces that lead to inaccuracy have also been challenging to address in force sensors. The cost and complexity of force sensors has also been an issue. Part of the complexity of force sensors is accentuated when trying to make them small enough for the desired force sensor application.

[0007] In modern touch applications, it is desirable that provisions for touch force location and/or measurement not increase the size or dictate the appearance of the touch equipped device. This is especially true in portable and hand-held applications. Conventional force sensors of the type required are typically much thicker than resistive or capacitive films, thereby potentially increasing the thickness of devices that incorporate such force sensors compared to devices that incorporate resistive or capacitive sensors. Since conventional force sensors of the type required cannot easily be made transparent, they cannot be placed in front of an active display area. As a result, devices including such conventional force sensors must typically be made wider than a resistive or capacitive based device to accommodate the force sensor. Thus, force-based touch technology is potentially disadvantageous with respect to both overall device thickness and width, when compared with other touch sensor technologies.

[0008] Most force-based technologies include some type of transducer that is sensitive to an applied force. One example of a known force sensor is disclosed by Serban et al., U.S. Pat. No. 6,531,951. Serban discloses a force sensor that includes at least one electrode that is spaced apart from a contact element. When a sufficient force is applied to the contact element, the contact element and electrode are brought into contact with each other to create an "on" signal. When an insufficient touch force is applied to the contact element, the force sensor remains in an "off" condition. Serban discloses a separator structure positioned so as to space the contact element away from the electrode when in a rest state. The size of the separator particles defines the distance the contact element must travel between a rest state and a position in which it contacts the electrode. The distance defined by the separator structure thus relates to the amount of force required to generate an "on" signal in the force sensor.

[0009] The prior art fails to disclose a force sensor that can detect a range of different applied forces from a very light applied force to an impact force with the level of accuracy required for many touch applications, while still provided the size limitations for certain force-based applications.

SUMMARY OF THE INVENTION

[0010] In one of its aspects, the invention provides a novel capacitive device configured to detect differences in an applied force over a continuous range of applied force that includes zero force. The device includes first and second electrodes that are spaced apart a predetermined distance from each other in a rest position. A measurable capacitance exists between the first and second electrodes. Structured elements having a predetermined maximum dimension are positioned in the device to control the predetermined distance between the first and second electrodes. An applied force to the device causes a change in the distance between the first and second electrodes and a related change in the capacitance that can be measured to determine information related to the applied force.

[0011] In another aspect of the invention, a capacitive force-based touch sensor assembly includes a frame, a touch sensitive surface, and multiple force-activated devices positioned between the touch sensitive surface and the frame. The force-activated devices detect an applied force to the